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A. Significance

What does it take to succeed in school and in life after school? Among the most compelling of modern developmental findings is that general intelligence does not predict students' academic success as well as students' 1) capacities to act when success is uncertain, 2) consider alternative paths when an initial course seems blocked, and 3) persist when tasks become difficult. Research shows the impact of increasing "noncognitive" factors on student academic achievement and success (for a review, Farrington et al., 2012). Noncognitive factors, or the strategies, attitudes, and behaviors that lend themselves to cognitive performance and learning, include academic behaviors, perseverance, mindsets, learning strategies, and social skills. The *Identity-Based Motivation Journey to Academic Success* (*IBM Journey*) development project addresses **Absolute Priority 4** by focusing on academic perseverance, mindsets, and learning strategies. Specifically, the noncognitive factors targeted are the factors underlying identity-based motivation (IBM). As explained next, these are **connection**, **confidence and certainty about strategies**, and **productive interpretation of experienced difficulty**. In addition, *IBM Journey* will address both **student achievement** and **student growth**.

IBM predicts that people are motivated to act in identity-congruent ways but are sensitively attuned to cues as to what their identities mean and, hence, what they imply for behavior. Future possible identities (also called possible selves) influence current choices if they feel **connected** to the present self. Connection increases the likelihood that people experience confidence and certainty that they can attain relevant possible identities and use **strategies** to attain these possible identities. Connection also increases likelihood of having productive **interpretation of experienced difficulties** along the way—productive in the sense of perceiving experienced difficulties as signals that the task is important to attaining a future identity rather than a signal that that identity is impossible to attain. Connection, confidence and certainty about strategies, and productive interpretation of experienced difficulty are related so that increases in one should yield increases in another. For example, prior research has documented that the effect of productive interpretation of experienced difficulty on certainty of attaining academic possible selves and using relevant strategies such as studying (Smith & Oyserman, 2015).

Our team includes project team leaders, **Katie Stringer Andersen** (McREL International) and **Daphna Oyserman** (University of Southern California) and the South Central Board of Cooperative Educational Services (SC BOCES) in Colorado. Stringer Andersen is an adolescent and identity researcher and program developer and evaluator with a decade of large-scale project management experience. Oyserman developed IBM theory, tested its efficacy as a school-based intervention and has led numerous studies testing the effects of each of its core components on academic outcomes. The two have already started collaborating on development of STEM-IBM measures. The SC BOCES has 12 member school districts, 10 rural (remote or distant) and two remote towns, with a total student population of 4,388 students in preK to 12th grade, of which over 58% are eligible for free and/or reduced lunch and 47% are minority, fitting the ***high-needs*** i3 directive. Our team is partnering with Filament Games, an educational game developer, with a deep base in relevant expertise, having developed over 90 serious games in the past decade focused on this age range. To create the digital *IBM Journey* game for use in 7th to 11th grade, we will use an iterative development process including process evaluation. Our goal is to develop a school-based, scalable intervention for middle and high school students based on the prior successful development and implementation of the effective School-to-Jobs intervention (Oyserman, 2015; Oyserman, Bybee, & Terry, 2006) using a digital serious game instead of face-to-face classroom based intervention led by facilitators. A digital serious game is one in which video is used to create scenarios using game content tied to learning objectives. The game will be implemented and evaluated using a block randomized design to both evaluate its impact on student academic engagement and achievement and to test the mediating effect of IBM "noncognitive" factors. Students in the active control condition will play other serious games meant to teach specific content (e.g., the Bill of Rights) but not to evoke IBM. Therefore, the project will document effects of the *IBM Journey* game compared to other digital serious games, eliminating the possibility that any effects are due to the motivating effect of playing computer games in school. By testing the posited mediating effect of IBM factors, results will document whether effects are due to the theorized process model.

IBM theory provides an explanation of aspiration-attainment gaps in academic outcomes based on three core elements: 1) connection to one's future self, 2) certainty about strategies, and 3) productive interpretation of experienced difficulty (for a review, Oyserman, 2013). First consider connection. Whether or not imagining future possible identities or the future self, in general, influences current schoolwork depends on whether these possible identities are experienced as connected to the present self (Destin & Oyserman, 2010). IBM theory predicts that individuals persist through difficult tasks when they experience **connection** between current and possible future selves. In other words, when students perceive that their future self is part of their current identity, the future feels imminent and tangible, and hard work becomes necessary and pressing. However, contextual cues either support or undermine experienced connection—for example, by making the future self feel more or less vivid, by implying that the future self is included or excluded in current time, or by bolstering or undermining certainty of their path and strategies to attain their future self. Connection can be cued by manipulating how time is considered (Lewis & Oyserman, 2015), via an envisioned path from me now to me then (Destin

& Oyserman, 2010; Landau, Oyserman, Keefer, & Smith, 2014) or imagined strategies that link current actions to future success (Oyserman, Bybee, Terry, & Hart-Johnson, 2004; Oyserman, Johnson, & James, 2011). Interventions that support conceptualizing connection between current and future selves improve focus and willingness to delay gratification and improve academic outcomes over time (e.g., Lewis & Oyserman, 2015; Oyserman et al., 2006).

Students who fail to experience connection are more likely to interpret experienced difficulties along the way as an indication that attaining one's future successful student self is "impossible for people like me" (Oyserman et al., 2006; Oyserman & Destin, 2010; Smith & Oyserman, 2015). It is not that other students do not experience schoolwork as difficult, rather, cues such as connection to future self can lead students to a more productive interpretation of their experienced difficulty. Indeed, students led to interpret their **experienced difficulty as an indication that the task is important** show improved academic attainment, whether they are in middle school (Oyserman et al., 2006) or college (Smith & Oyserman, 2015). Effects are equally robust for low-income, disadvantaged minority, and English language learner (ELL) groups (Oyserman, Terry, & Bybee, 2002; Oyserman et al., 2006; Papi & Abdollahzadeh, 2012).

Students with more strategies to work toward positive and away from negative future academic identities attain better grades over time (Oyserman et al., 2004). But students may feel uncertain and lack confidence in their ability to develop strategies. Landau et al. (2014) demonstrated that it is possible to increase student's **certainty and confidence about strategies** to achieve a desired future identity and that this actually increases their experienced connection to their future self. Specifically, students led to have stronger identity connection (by increasing their certainty and confidence about strategies) planned to spend more time on academics than on social activities and did indeed attain better final exam grades than students in a number of different control groups. These effects are important because they were the result of simply viewing images that evoked agentic journey metaphors, rather than passive versions of the same metaphor, or alternative non-agentic metaphors, such as containers. The process underlying the power of these images is conceptual metaphor theory (Gibbs, 2011; Landau, Robinson, & Meier, 2013; Lakoff, 1993), which emphasizes how metaphors translate abstract constructs, such as time or future self, into concrete ones. Then they carry with them relevant mental images and action tendencies. Students' abilities to imagine their future selves and visualize the path forward are instrumental for their moment-to-moment decisions about whether and when to get going or give up (Oyserman et al., 2004).

Oyserman translated each of the IBM components into activities used in the School-to-Jobs (STJ; Oyserman, 2015; Oyserman et al., 2006; Oyserman et al., 2002) intervention. Randomized control trials highlight that the STJ intervention can be delivered with fidelity, that it is low cost (about $180 per person, and that it yields sustained improvement in academic outcomes over time (Oyserman, 2015). However, to be scalable, the active ingredients of STJ need to be deliverable within the school system without grant-funded facilitators. There are two ways to do this: utilize a "train-the-trainer" model to teach teachers to train other teachers or to develop a digital delivery-method. The former method is currently being tested (Oyserman & Sorensen, IES Grant # R305A140281). The latter method is the goal of the *IBM Journey* proposal. Each of these approaches has advantages and disadvantages. Focusing on teachers addresses the question of scale and has the advantage that teachers who have an IBM mindset can be potentially more effective in their teaching. The disadvantage is that teachers need to be able to deliver the intervention with fidelity. Using a digital platform means that issues of fidelity are less likely to undermine the effectiveness of the intervention and does not require as much of teachers. Moreover, the digital platform facilitates a larger scale test of the effect of intervening in different grades, something that is less feasibly tested in a teacher-delivery model. Finally, the *IBM Journey* implementation tests an even briefer intervention than the original STJ, which took about ten hours of classroom time. *IBM Journey* plans to take under three hours of classroom time, and resources required for school use are computers and time to download and install the game.

The project team will translate IBM components using the journey metaphor and as expressed in STJ into the *IBM Journey* game to guide middle and high school students to have IBM. STJ was developed for high needs students and first tested as an after-school program (Oyserman et al., 2002) then implemented twice weekly as an in-class program in an NIH-funded randomized trial of 264 primarily African American 8th grade students in Detroit Public Schools (11 sessions over a seven week period, Oyserman et al., 2006). Using multilevel modeling, the study found that by the end of 8th grade, STJ students (both the intention to treat and compliant samples) showed significant changes in student reported absences (Cohen's d = -.27, unexcused absences (school records; effect size = -.73), GPA (Cohen's d = .25), and standardized test scores (proportion passing; Cohen's d = .36). STJ students attended school more than two additional days than the controls. Impact across each of these outcomes persisted and grew over time. By the end of 9th grade, STJ students spent significantly more time doing homework (nearly an hour more per week; Cohen's d = .74), were more likely to take initiative in class (Cohen's d = .32*)*, were less likely to miss class (average of 2.25 more days in school; Cohen's d = -.30), and had higher GPA (Cohen's d = .30) than control students. The effect of STJ on academic outcomes was mediated by its effects on the posited elements of IBM. As noted, the fully manualized STJ intervention is currently being taught to teachers in Chicago public schools to test feasibility of a teacher-trained, teacher-led version of IBM (Oyserman & Sorensen IES Grant #R305A140281). The proposed *IBM Journey* game builds on this work, aiming to develop a multi-segment game that can be used in classrooms with fidelity and at scale across middle and high school.

National Significance

Nationally, most students want to do well in school; 95% of students want to go to college (ACT, 2013), yet about one-fifth of students do not finish high school, and while over half of high school graduates start college, only about half of those who start college graduate with a bachelor's degree within 10 years (Kena et al., 2015). An obvious disparity exists between what youth aspire to and what they attain, and that disparity is greatest for high-need students; only 14% of low socioeconomic status students compared to 60% of high SES youth, attain a bachelor's degree within 10 years (Kena et al.). The proposed sequential development and rigorous testing of the *IBM Journey* game addresses the national need for a scalable brief intervention that can be used with fidelity across middle and high school years that addresses noncognitive factors essential to bridging aspirations and actual attainment in school. The *IBM Journey* will leverage IBM theory and its empirical base to develop game modules richly infused from student input to make the end product engaging, useful, and effective. As a consequence of this project, the *IBM Journey* game will be rigorously tested in school settings allowing for clear indications of the target audience (e.g., which grade levels) and for what outcomes this intervention works. Once tested, the *IBM Journey* game will be available for use in schools. Schools will know for which students, at which grades, and for which outcomes it works. *IBM Journey* may also be useful in other settings, including outside of school, something that future grant applications could address.

Potential Replicability

This project will develop a final product—the digital *IBM Journey* game. Strategies for implementation will be well documented as part of the teacher piece of the final product. Because *IBM Journey* is a digital product, it addresses many of the fidelity of implementation problems, feasibility and scalability of implementation interventions often face. With regard to fidelity, teachers do not need to be trained and validated in their delivery of the IBM components as they do if they are delivering it themselves. With regard to feasibility, *IBM Journey* will be even more feasible to deliver than the original STJ intervention because its 10 modules, each only 10 to 15 minutes to complete, will not take more than two and a half hours of time. In addition, it will be low cost to implement, as time and resources are all that is required to install the game on computers. This limited footprint means that *IBM Journey* can be implemented in an array of classroom settings. With regard to scalability, we will test *IBM Journey* across grade levels. This means that school systems will be able to know which grade levels are appropriate for its implementation. Future research will be needed to test effectiveness in out of school settings but the game itself is portable. The *IBM Journey* game will include a brief teacher-focused introductory overview, its purpose, how to use it, and potential techniques to facilitate its use. Requirements are access to individual computers for 10 to 15 minute segments, twice a week, for up to five weeks at the beginning of the school year. The proposed project will produce information about the appropriateness of the *IBM Journey* game for the middle and high school settings.

B. Quality of the Project Design

The **goal** of *IBM Journey* is to increase 7^{th}-11^{th} grade IBM and, resultantly, student achievement by developing and implementing a serious digital game. Stringer Andersen

(McREL) and Oyserman (USC) are partnering with the SC BOCES of Colorado and Filament Games to address the following objectives for the project:

1) Develop a digital serious game that uses the core components of IBM as operationalized in STJ to guide students to think of current and future selves as connected and of themselves on a journey as the active driver making choices, addressing difficulties and obstacles along the way.
2) Test and implement the *IBM Journey* game in 7th – 11th grade classrooms
3) Document *IBM Journey* game effects on the following:
    a. Increased student IBM for academic success
    b. Increased student school engagement
    c. Increased academic success

The logic model (**Figure 1**) depicts how these objectives will be achieved.

Inputs	Activities/ Participation	Mediators	Outcomes
Iteratively developed digital game that: • Is based in IBM research and the tested Schools-to-Job intervention • Primes connection interpretation of experienced difficulty, and procedural confidence using a journey metaphor	During the first two months of the academic year, as part of the school day, LEA systematically implements IBM Journey game with 7th-11th grade students 7th-11th grade students complete the IBM Journey game's 10 modules during a school semester	Increase in students' experienced connection between current and future selves. Increase in students' experienced confidence that they can attain their successful student possible selves and use relevant strategies to become successful students Increase in students' productive interpretation of experienced difficulty as importance and reduction in unproductive interpretation of difficulty as impossibility	Increase in student self- and teacher-reported engagement with school Increase in student attainment as operationalized by school grades (GPA) and standardized test scores

Assumptions: Funding to support digital game development; game developer; LEA partner and students in LEA who need to improve academic achievement; and expertise in IBM, educational technology, and iterative development; advisory boards of middle and high school students and teachers; external evaluator to test program effectiveness

Figure 1. Identity-Based Motivation Journey to Academic Success Digital Game Logic Model

The Power of Digital Serious Games

Ninety-seven percent of U.S. teens play some sort of digital game on regular basis (Lenhart et al., 2008). This means that digital games are a vehicle that could be used for intervention. Specifically, so-called ‘serious games’, games with explicit theoretically grounded educational purpose, are considered a vehicle for providing accessible educational and motivational experiences (Abt, 1970). The National Research Council’s (2011) report specifies that it is important that digital games have specified learning outcomes and strategies for achieving them, as well as methods for continual improvement. The promise of serious games is that they can provide an immersive and safe context within which users learn not only from successes but also from failures, to acquire and test not simply subject knowledge and skills but also identities (e.g., Bellotti, Berta, & De Gloria, 2010). A number of reviews of digital games in the K-12 years show promising results on student achievement compared to controls. These include a review of over 300 articles (Young et al., 2012), the National Research Council’s (2011) report on digital gaming in science education, and Clark, Tanner-Smith, and Killingsworth’s (2014) systematic review and meta-analysis. However, serious games are still in their infancy in terms of their grounding in empirical evidence of how learning and motivational processes occur and how these processes impact student achievement (Greitzer, Kuchar, & Huston, 2007; Mayo, 2009; Young et al., 2012). Nevertheless, serious games that are steeped in learning and motivational theories show that this can be done (e.g., Coller & Shernoff, 2009; Miller, Chang, Wang, Beier, & Klisch, 2011; Papastergiou, 2009). The planned *IBM Journey* intervention builds on **strong theory (see Appendix D)** and its prior translation to intervention (as STJ). Hence, we expect that our planned game will yield the expected effects on academic engagement and achievement via its effects on the core IBM processes.

Digital game Development

In order to address the **first objective**, developing the *IBM Journey* game, the STJ journey metaphoric language and activities will be enhanced by use of a digital platform that create vivid images of these metaphors. The game will consist of no more than 10 modules of 10 to 15 minutes each based on the effective STJ intervention activities, each of which cultivates components of IBM (see **Table 1**). See **Figure 2** for Filament Games' mockup game screens.

[redacted]

In the first module set, activities are based on the initial sessions of STJ (Oyserman, 2015; Oyserman et al., 2006) and follow-up research on the conditions in which students feel connected to their future self (Oyserman & Horowitz, in press). In these sessions, students are guided to consider visions of themselves as adults, to create a vivid representation of themselves in adulthood, to consider strategies they are using now that might help them attain future selves, and even to see their avatars change over time. These processes create a vivid sense of one's possible future identities and connect present and future selves, increasing the sense that the future is imminent and requires current action. The second module set builds on the timeline activities tested in STJ (Oyserman, 2015; Oyserman et al., 2006) and the careful test of the influence of a vivid journey metaphor as later separately tested in Landau et al. (2014). Students will start with a general journey timeline. This activity facilitates structuring a sense that there is some order to the future, that choices now matter for later opportunities, and that failures and obstacles (roadblocks) are normal and can even signal that a task is important. Next, students will receive a chance to examine, in more detail, segments of their timeline set in the nearer future. The segments will be set by developmental level so that middle school students will be alerted to consider steps, choice points, and stumbling blocks on the way from middle school to college (**Figure 3** left panel) and high school students will start with high school and consider steps through college and beyond (**Figure 3** right panel).

Figure 3. Segments in the IBM Journey timeline activities

Examples of obstacles from students in STJ include failing to make a cutoff grade to get into a competitive high school, becoming homeless, and having to move to a different school because of family problems. By using a journey metaphor, the game makes progress into the future, an otherwise abstract notion, concrete, and as documented by Landau et al. (2014) also clarifies steps along the way and increases certainty that one can take them. The journey metaphor also facilitates a productive interpretation of experienced difficulty. Journeys have difficulties but no one simply sits down and stops trying. Happy or unhappy, they keep going, getting around obstacles, trying again if forks in the road lead to dead ends. At its most basic level, the journey metaphor is about agentic locomotion. Everyone knows how to walk, slowly or quickly depending on the situation. This knowledge of journeys carries over to interpretation of future self, as demonstrated by Landau et al. (2014).

The <u>third module set</u> focuses on the last set of STJ activities. In these activities students engage with puzzles and everyday problems in school to reinforce the idea that experienced difficulty can mean that the task is important and requires creative and sustained action. The puzzles and problems are set up so that other students' solutions are shared and students gain a sense that their experiences are common and not due to unique vulnerabilities.

[redacted]

Iterative development. To address our **second objective** (testing and implementation of *IBM Journey*), iterative development will occur in Years 1 and 2; implementation using school computers will occur in the second half of Year 2; and follow-up will occur in Years 3 and 4, with final reporting in Year 5. The questions that will guide the iterative process are as follows:

1) To what extent does realism in features of the game (e.g., the setting of the journey within the game, age-linking of the avatar for each segment of the journey) matter?
2) To what extent do students of different ages differ in the appeal of setting their own elements of the game (skills, forks in the road, stumbling blocks) vs. having relevant elements of each time appear in the game?
3) To what extent do students of different ages differ in the appeal of direction of animation (locomoting toward the future self or a future self locomoting toward the present self)?

First, the project team will create a storyboard for the digital game and solicit feedback on it from advisory boards of teacher and students, serious games advisers, and content experts. Teachers and students will focus on their visual experience, enjoyment, and interest; serious games advisers will focus on the technical aspects of the game; and content experts (graduate students in education and psychology) will rate the game modules against operationalizations of the core IBM constructs. Once the game is fully developed, it will be tested on the Amazon Web Services platform (hosting and storage) twice with the student/teacher and serious game advisory boards providing feedback that will be used as a basis for refinements of the game. Re-testing with concept experts will then be completed by a different set of graduate students in psychology and education, who will rate the revised modules against IBM core concepts. Finally, in each iteration, we will use cognitive interviewing ("think aloud") with students to provide an explanation of what they are thinking as they encounter each segment of the game. This strategy will be used again after game implementation. Teachers will provide feedback on the introductory guide that introduces the game, its intended use, and potential ways to facilitate its use. The final game will then be launched for full implementation (Fall 2017, second half of Year 2), with impact evaluation in Years 2 to 4, analysis, write-up and dissemination occurring in Years 3 to 5.

Management Plan

Table 2 highlights the significant roles and responsibilities for the project management team and subcontractors. One strength of the *IBM Journey* project is the strong partnership among SC BOCES and researchers. Researchers will work closely with the SC BOCES *IBM Journey* site coordinator, in monthly meetings, to ensure objectives regarding iterative development, implementation, and evaluation are met. See **Appendix F** for key personnel resumes. **Table 3** presents all significant milestones as they align with the previously presented logic model (**Figure 1**). Key project components include digital game development (inputs) and game implementation (activities/participation). Evaluation and dissemination activities also will be occurring throughout the project (see **Table 4** for overall project timeline and **Table 5** for evaluation timeline). The Co-Directors will have biweekly calls to discuss project activities. As part of the evaluation and dissemination efforts and in addition to external fidelity and impact evaluation, extensive analyses will be conducted by the Co-Directors to examine the game, student response through cognitive interviewing, and exploratory questions related to differential effects for different types of students (e.g., ethnic minority, SES). Analyses and write up of papers for publication will occur throughout the project, but Year 5 will be dedicated to final reporting, exploratory analyses, larger dissemination efforts, and LEA hand-off. In Years 4 and 5, SC BOCES schools will be able to implement the game with all of their middle and high school students if desired, ultimately serving over 2,500 students over the course of the project.

To **disseminate** this project, we will take three routes. First, we will publish the results of our study in academic journals in psychology and education, as well as practitioner-focused journals. We will also publish at least one article in a practitioner-focused journal with the SC BOCES and/or school personnel it serves as co-authors. Second, we will present the results of our study at conferences in psychology and education. Third, we will include information about the project on the USC Center for Mind and Society's webpage (http://dornsife.usc.edu/mindandsociety) and McREL's Solutions Portal (free version; http://portal.mcrel.org/) and include links to project outcomes, as well as YouTube and other video. Papers and conference presentations will begin in Year 2, and general dissemination efforts will begin in Years 1. The game itself will be available to the participating school district and other participating schools as part of the final development process. The *IBM Journey* game will be available on the USC Mind and Society webpage and McREL's Solutions Portal for use generally, with the cost of maintaining the website as a nominal ongoing cost. It will be clearly identified as jointly developed by Oyserman at USC, Andersen at McREL, and the game development team at Filament Games with i3 funding. SC BOCES and its districts will be named they wish.

Table 2. Significant Roles and Responsibilities

Title	Key Responsibilities
Key Personnel	
Project Co-Director and Adolescent Expert (Katie Stringer Andersen, Ph.D.)	Serve as co-director of the project. Supervising and managing the implementation of the i3 development project and dissemination of project findings. Conduct think aloud testing and cognitive interviewing with students. Manage student and teacher advisory board participation. Facilitate changes in the project using formative data as part of the iterative design process, convene and coordinate information sharing among key leadership teams and advisers. Co-coordinate the iterative development of the game through designing the process in which feedback will be collected and utilized to make refinements. Conduct exploratory analyses to examine specific aspects of the game, its development, and impact.
Project Co-Director and IBM and Priming Expert (Daphna Oyserman, Ph.D.)	Serve as co-director of the project team with the responsibility of ensuring that the project goals and aims and deliverables are carried out including academic publications, dissemination, and website. Expert on the translation of IBM to actual game tasks and components using data collected and analyzed by the project team; facilitate changes in the project using formative data as part of the iterative design process supervise and provide guidance on additional exploratory research questions outside of the external evaluation. Co-coordinate the iterative development of the game through designing the process in which feedback will be collected and utilized to make refinements. Conduct exploratory analyses to examine specific aspects of the game, its development, and impact. Each of these activities will involve a graduate student research assistant who will assist in these efforts.
SC BOCES Site Coordinator[a] (to be hired within 60 days of grant start)	Serves as a bridge between the LEA and other project staff. Coordinate the recruitment for student and teacher advisory boards. Coordinate the implementation of the intervention and evaluation activities in the LEA as directed by the project team by facilitating collecting, de-identifying, and reporting data, maintaining fidelity of the student randomization, providing technical assistance to teachers and school staff as the intervention as implemented.
Key Leadership Teams and Advisers	
Game Developer (Filament Games)	Work with the project team members to execute the vision for the game through storyboard creation, develop a fully functional game for use with 7th-11th grade students
Student Advisory Boards[b] (Middle and high school)	Provide feedback on the game development and its implementation and use
Teacher Advisory Board[c] (Middle/high school teachers)	Provide feedback on introduction to the game and the game development and its implementation and use
Serious Games Advisers (Benjamin Shapiro, Ph.D., Benjamin Nye, Ph.D.)	Provide feedback on the game development, its implementation, and provide solutions for any issues that may arise related to development and implementation.
External Evaluator (Kristen Bub, Ph.D.)	Design and implement fidelity of implementation and impact and exploratory evaluation studies.
USC psychology Ph.D. student	Assist Oyserman in each of the specified activities.

[a] SC BOCES will hire individual; project team will provide input on selection of this individual and be trained by Dr. Andersen
[b] students in the advisory board will not be intervention participants but will be served by the LEA and of the age group and demographics of intervention participants
[c] teachers in the advisory board will not have students in the intervention but will be in the LEA and have taught 7th-11th grades

Table 3. Milestones for IBM Journey Components as Aligned with the Logic Model

Milestone	Deadline	Lead	Logic Model Component
Create storyboard of game (Design phase)	Mar 2016	Filament	Digital game development
Solicit student, teacher, and serious games advisory feedback on storyboard	May 2016	Andersen	Digital game development
Work with Filament to ensure storyboard fits IBM and conceptual metaphor theory, test this link with content experts	Mar 2016, Aug 2016	Oyserman/GSRA	Digital game development
Incorporate feedback on storyboard/ Develop first iteration of digital game	Aug 2016	Filament	Digital game development
Test the first iteration of the game with students, teachers, and serious games advisers	Aug 2016	Andersen/ Oyserman/GSRA	Digital game development
Incorporate feedback on first test and second, final version of digital game ready	Oct 2016	Filament	Digital game development
Second digital game test with students, teachers, and serious games advisers	Nov 2016	Andersen/ Oyserman/GSRA	Digital game development
Create introductory guide	Dec 2016	Andersen/ Oyserman/GSRA	Digital game development
Solicit teacher feedback introductory guide	Jan 2017	Andersen	Digital game development
Incorporate feedback on introductory guide	Feb 2017	Andersen/ Oyserman/GSRA	Digital game development
Final game pilot testing with students	Apr 2017	Andersen/ Oyserman/GSRA	Digital game development
Schools establish process for implementing the game	July 2017	Site-Coordinator	Implementation
Students use the game	Aug 2017	Site-Coordinator	Implementation
Students complete the IBM Journey game modules	Oct 2017	Site-Coordinator	Implementation

Note: GRSA = graduate research assistant; all times were confirmed with Filament Games' standard processes

Table 4. Overall Project Timeline

Activity	Year1 (2016)				Year 2 (2017)				Year 3 (2018)				Year 4 (2019)				Year 5 (2020)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Iterative game development																				
Pilot implementation																				
Preparation for implementation in LEA																				
Implementation in LEA (Time 1: RCT 7th-11th grades) (Time 2 and 3: All 7th-11th grades)																				
Fidelity data collection																				
Primary data collection																				
Secondary data timing																				
External evaluation analysis and reporting																				
Dissemination																				

C. Quality of Project Evaluation

Dr. Kristen L. Bub will conduct the external implementation fidelity and outcome evaluation of *IBM Journey*. The project team will engage in an iterative development process, and the evaluation of this process will ensure that developers are utilizing and incorporating feedback from the Advisory Boards. Dr. Bub will review feedback from the Advisory Boards and documentation of how the developers intend to address their feedback quarterly in the first 18 months of the project and provide feedback via monthly and/or quarterly calls. In addition, fidelity of implementation will be evaluated when the *IBM Journey* game is implemented in the Fall of 2017. The impact evaluation focuses on student outcomes, including IBM, achievement, and engagement, between year-end (end of 7^{th} to 11^{th} grades) and end of the next school year (end of 8^{th} to 12^{th} grades) and involves quantitative data provided by students and teachers.

To meet the **third objective**, documenting effectiveness of *IBM Journey*, a randomized block design (RBD), where schools serve as "blocks" and students are randomized to treatment and active control conditions, will be employed. Such a design reduces variability within a block, thereby producing less biased and thus stronger estimates of the treatment effect within each block. To minimize the possibility that school factors explain differences in student outcomes and to make inferences to the schools served by the LEA, school effects will be fixed, eliminating the need to account for nesting analytically. It is expected that positive effects of *IBM Journey* on changes in academic achievement or engagement will be mediated by changes in IBM. Exploratory analyses will focus on testing moderation of the main effects and mediation models by grade level (e.g., middle versus high school) using multi-group analysis in structural equation models (SEM).

Research Questions. Because STJ had impacts on students beyond one year post-implementation, research questions address whether the same is true of the *IBM Journey* game. Using a RBD, two confirmatory and one exploratory question will be addressed:

a. Does game use have a positive impact on academic and IBM outcomes? We test this by comparing the intervention and active control groups both cross-sectionally (immediately post, six months-post, and 18 months-post game use) and over time. Specifically, we test differential growth in student academic outcomes (engagement, GPA) and IBM outcomes (connection, interpretation of difficulty, certainty that can work on possible selves and use strategies) between intervention and active control condition.

b. Is the impact of game use on *changes* in academic outcomes over time mediated by *changes* in IBM outcomes over time?

c. Is the impact on game use on both cross-sectional and growth in student outcomes different for middle school (7th and 8th grades) and high school (9th – 11th grades)?

Procedure, Sample, and Measures. Prior to data collection, IRB approval will be obtained. In addition, all necessary approvals to receive de-identified student level achievement and administrative data will be obtained. The **sample** will consist of at least 1,600 students in 7th to 11th grade (M = 140 students in 7th-11th grades) within the SC Colorado BOCES who will be randomized to treatment and control groups. The sample represents 12 school districts with varying school sizes. Treatment is defined as use of the game twice a week in the fall (first academic semester) of the school year. Control is defined as playing an alternative educational game that is academic-content-driven (e.g., learning about the constitution and should not impact IBM). The SC BOCES serves 47% minority students and 58% students eligible for free/reduced lunch in 20 schools in the 7th-11th grades. Before and after game use, treatment and control students and their teachers will complete a brief battery of **measures** to test whether the mediators and outcomes specified in the intervention logic model are influenced by the game. See **Table 5** for measures and timing.

Table 5. Measures and Timing

Indicators/Measures /Data Source(s)	Description	Timing
Student achievement – Administrative data, GPA and standardized state test	*GPA* is the standardized grade point average, 0 to 4.0 for students. *Standardized state test:* Partnership for Assessment of Readiness for College and Careers (PARCC) (English language arts and literacy [ELA-L] and math subtests); performance-based assessment master claim scores will be used for the outcome analyses. Total points that can be scored are 137 (ELA-L) for grades 6-11, 82 (math) for grades 3-8, and 107 (math) for grades 9-11. Both will be obtained, de-identified, from the LEA for the analytic sample each year.	May 2017 (pre), Dec 2017 (GPA only), May 2018, 2019
IBM: connection between current and future self (Lewis & Oyserman, 2015) – Student surveys	4 items (7-point scale); Example items: "The person I am now and the person I will be <X years/months)> are pretty much the same person" and "When I try to imagine the person I will be in <X years/months)> it is as if I am imagining a person other than myself." Internal consistency ($\alpha = .81$) and convergent validity established.	
IBM: confidence and certainty about strategies (Kemmelmeier & Oyserman, 2001) – Student surveys	7 items (10-point scale) Two scales: 1) 4 items rating the extent to which strategies would describe them in the coming year (e.g., "using my time wisely," "coping well with distractions") and 2) 3 items rating the extent to which possible selves would describe them in the coming year (e.g., "doing well in school," "getting good grades"). Internal consistency ($\alpha = .80$ and .88, respectively with moderate correlation of .45, $p < .05$) and convergent validity were established.	
IBM: interpretation of experienced difficulties (Oyserman et al., 2015) – Student surveys	2, 6-item measures (7-point scale) of interpreting difficulty in a task as a sign that the task is impossible or important: 1) possible self is "for me" (e.g., "When I'm working on a school task that feels difficult, it means that the task is important") 2) possible self is "not for me" (e.g., "When I feel stuck on a school task, it's a sign that my effort is better spent elsewhere"). Both have established internal consistency ($\alpha = .89$ and .83) and convergent validity.	
Student attendance - administrative data, unexcused absences	Unexcused student absences provided by schools	May 2017 (pre), May 2018, 2019
Student-reported engagement (Homework: Oyserman et al., 2006; classroom attention and concentration: Dornbusch & Steinberg, 1990) – Student surveys	*Homework*: Closed ended question "How many hours a week do you usually spend doing homework?" using a 1-week event history calendar (Belli, 1998). *Classroom attention and concentration*: 2 (attention and concentration items) of the 4 items of the Student Engagement Questionnaire; students are asked, "How often do you really pay attention during each of these classes?" and "How often does your mind wander in each of these classes?" (6-point scale for English/language arts, social studies, math, and science). α ranged between .74 and .86, and predictive validity has been established (Fredricks, McColskey, Meli, Mordica, Montrosse, & Mooney, 2011).	May 2017 (pre), Dec 2017, May 2018, 2019
Teacher reported disruptive and initiative behaviors (Finn Initiative Scale; Finn, Pannozzo, & Voelkl, 1995; Oyserman et al., 2006) – teacher surveys	Teacher-reported ratings of each student using 2, 4-item (5-point scale) scales: 1) initiative (e.g., "How often does this student… do more than the work assigned?," "…persist when confronted with difficult problems?") and 2) disruptive behavior (e.g., "This student annoys peers or interferes with peers' work," "…is critical of peers who do well in school"). α ranged from .75 to .85, and validity was established in Oyserman et al. (2006).	

Descriptive Analyses. Distributional properties of the outcome and predictor variables will be examined by obtaining standard summary statistics, bivariate correlations, and bivariate scatterplots for all variables in **Table 5**. Treatment and control group comparisons on demographic, IBM, and academic data pre-intervention will be conducted, and significant differences will serve as controls in predictive analyses. A set of confirmatory factor analyses within the SEM framework will be conducted to investigate whether the observed IBM and academic indicators can be represented more parsimoniously by latent constructs. Should it be determined this is not the case, models described below will be estimated using observed indicators rather than latent constructs.

Does game use have a positive impact on academic and IBM outcomes in comparison to the active control condition? Latent Growth Curve Analysis (LGCA) will be used to test direct associations between *IBM Journey* and changes in student IBM, achievement, and engagement from immediately prior to the intervention (herein referred to as pre-test) to 18 months following the intervention (herein referred to as the 18 month follow-up). LGCA teases out measurement error from the observation of a given behavior or skill over time, thereby disattentuating the findings of the influence of measurement error (Willett & Sayer, 1994). **Figure 3** depicts the direct links between *IBM Journey* and changes in a given outcome (e.g., IBM, achievement, or engagement). On the right side of **Figure 3** is a two-factor measurement model that links the hypothesized latent constructs representing achievement at each of the four time points to latent constructs representing true intercept (centered at the last assessment, thereby reflecting level of achievement at 18 month follow-up) and true linear rate of change between pre-test and the 18 month follow-up. On the left side of the diagram is an observed variable reflecting treatment status (i.e., *IBM Journey* or control group). Models would be fit separately for IBM, achievement, and engagement outcomes.

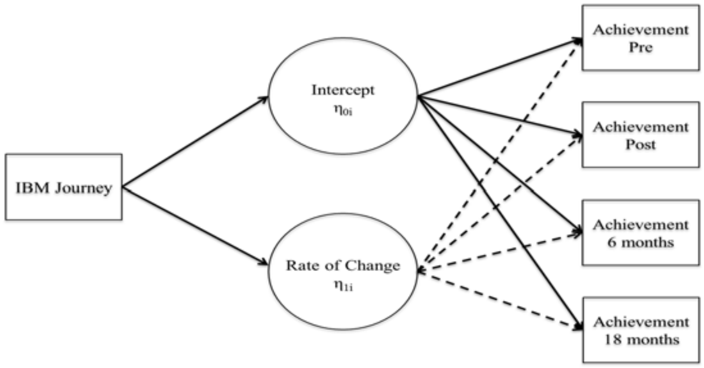

Figure 3. Growth Model for Examining IBM Journey Impact on Achievement

Note that because the complete longitudinal model cannot be fit until 18 months after completion of the intervention, we will also fit a series of auto-regressive models in which we regress achievement (or IBM or engagement) at a given time point (i.e., post-test, 6 month follow-up, or 18 month follow-up) on treatment status and all earlier assessments on those same constructs. For example, in one set of models we will regress achievement immediately following treatment on treatment status and pre-test achievement; in a second set of models, we will regress achievement at the 6-month follow-up on treatment status, pre-test achievement, and post-test achievement; and so on.

Is the impact of game use on changes in academic outcomes over time mediated by changes in IBM outcomes over time? To investigate the potential mediated pathways from *IBM Journey* to changes in the IBM variables and subsequently, to changes in student achievement or engagement, the model depicted in **Figure 4** will be tested. That is, the direct pathways from *IBM Journey* to changes in the latent construct representing IBM and changes in the latent constructs representing achievement (or engagement) will be simultaneously estimated. These associations are marked by solid black lines in **Figure 4**. Additionally, the model includes direct pathways from the intercept and rate of change parameters for IBM to the intercept and rate of change parameters in achievement (or engagement). These pathways are marked by dashed lines in **Figure 4**. Mediated models will be estimated using bootstrapping methods, which involves resampling with replacement across a large number of iterations (e.g., 5,000; Hayes, 2009; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). For each sample, values for the mediated pathway are estimated and a bias-corrected average is computed. These estimates can be interpreted as the effect of *IBM Journey* on changes in student achievement (or engagement) through changes in IBM.

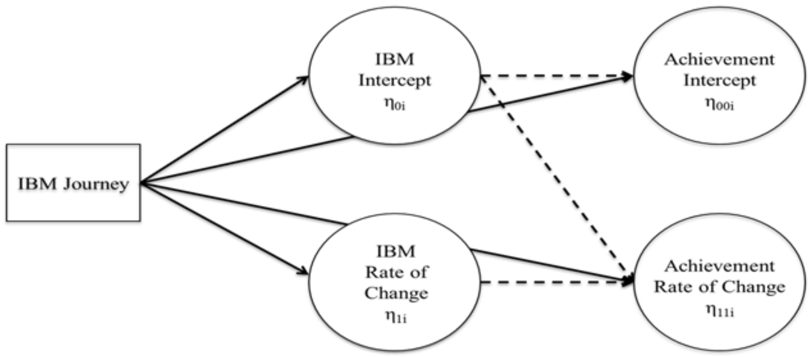

Figure 4. Mediational Model

Is the impact on game use on both cross-sectional and growth in student outcomes for middle school (7th and 8th grades) and high school (9th – 11th grades) different?

To examine differential impact of the *IBM Journey* game based on school level, multi-group SEM will be conducted to calculate Hedge's g for middle and high school levels, separately.

All models will be estimated in MPlus version 7.0 (Muthen & Muthen, 2014) and alternative models will be compared using a set of fit indices, including CFI, TLI, RMSEA, and chi-square statistics. Effect sizes will be calculated using Hedge's g. Although there are procedures in place to prevent attrition, it is not uncommon for some attrition to occur in longitudinal studies. As such, attrition analyses on pre-test demographics as well as IBM and academic outcomes will be conducted to determine whether attrition is systematic or random. Missing data in all models will be handled using Full Information Maximum Likelihood Estimation (FIML). Additionally, all models will control for the effects of a common set of student and school variables (e.g., free/reduced lunch and ethnic minority status) on each outcome. In an effort to account for possible developmental differences in identity development across the middle and high school years, we will first fit our models across all participants, controlling for grade level and will then fit separate models for participants in middle school (i.e., grades 7 and 8) and in high school (i.e., grades 9 through 11). In addition to estimating direct and mediated effects of *IBM Journey* on student outcomes, we will also use multi-group analyses to explore whether these associations are moderated by sociodemographic factors such as student gender, race/ethnicity. Our use of a RBD and well-established and validated measures as well as our efforts to minimize attrition (or account for it analytically) are expected to meet What Works Clearinghouse (U.S. Department of Education, 2013) standards without reservations.

Power Analysis. A priori power analyses using Optimal Design (Raudenbush, Spybrook, Lin & Congdon, 2011) were conducted to provide preliminary estimates of minimum detectable effects sizes (MDES) for a randomized block design using a sample of 20 schools with an average of 140 students per school. Using the harmonic mean of 99 and assuming an alpha of .05 and an R^2_{L2} of .65 (using pretest covariate), MDES is .09 at a power level of .90. Alternatively, using the parameters described above the MDES is .22 with a sample size as small as 15 per site). As few as 3 schools, using the parameters above and a harmonic mean of 90, MDES is .22. Thus, our average "block" size of 140 students is well-powered to detect a range of effects, anticipated to be .25 to .30 for GPA and .36 for standardized test proficiency (Oyserman et al., 2006).

Fidelity of Implementation. As described above, the primary purpose of *IBM Journey* is to impact student achievement and engagement. This can only be done if the program has been implemented in the way it was intended; that is, if adherence is high. As such, an extensive assessment of implementation fidelity will be conducted. Implementation fidelity, as specified by the activities/participation in the logic model in **Figure 1**, will be assessed using the methods listed below in **Table 6**. These aspects of fidelity reflect the adherence and exposure elements of Dane and Schneider's (1998) framework of intervention fidelity. During the development process, qualitative data from teachers and students will be collected to gather iterative feedback for the developers as they refine the game. Dr. Bub will review findings from the development process and evaluate whether feedback was incorporated into the *IBM Journey* refinements. Taken together, the evaluation provided during development will ensure the project team adheres to its planned development of the game, and the fidelity of implementation will evaluate the extent to which *IBM Journey* is implemented in each school as designed. Findings will represent the fidelity in a variety of schools—20 middle and high schools served by SC BOCES.

Table 6. Fidelity of Implementation Components

Critical Intervention Component	**Method for Assessment**
Systematic digital game implementation: twice a week, during school day, and in the first two months of the school year (Adherence)	Time stamp of time use
Student completion of game modules (Exposure)	Digital game use tracking
15 minute twice weekly game use among 7th – 11th grade students (Exposure)	Digital game use tracking

Sufficient Resources to Carry out Project Evaluation Effectively. The external evaluation team is led by Dr. Kristen L. Bub, who has over 18 years of research and evaluation experience in education and child/adolescent development. She has published work on LGCA for analyzing developmental data in the *Monographs of the Society for Research in Child Development* and has work utilizing LGCA in *Developmental Psychology*. Dr. Bub has served as a statistical and methodological consultant on several intervention and research studies and has received federal funding for her own research. Other staff for the external evaluation include a graduate research assistant.